Calcium isotopes: Possibilities for detecting past life on Mars

Donald J. DePaolo
Department of Earth and Planetary Science
University of California Berkeley
Berkeley, CA 94720-4767
USA)
depaolo@eps.berkeley.edu

Matthew S. Fantle
Department of Earth and Planetary Science
University of California Berkeley
USA

Wenbo Yang
Department of Earth and Planetary Science
University of California Berkeley
USA

The existence of life on Mars may be demonstrated with the isotopic composition of putative biogenic mineral matter. The isotopes of certain elements, in particular Ca, are fractionated mainly by biological processes, so the isotopic composition of carbonates and sulfates may attest to the past existence of life. Published work on Ca isotopes indicates that shell and bone is typically 1.5‰ lower in $\delta^{44}Ca$ than the environmental Ca source. Mineral matter decreases in $\delta^{44}Ca$ through food chains by about 1‰ per trophic level. Rocks and minerals that have not been affected by biological processing show little isotopic variation (±0.3‰ about the nominal bulk planetary value assigned as $\delta^{44}Ca = 0$). The expectation is that carbonates and sulfates on Mars will have $\delta^{44}Ca \approx 0$ if there has been no biological processing, and if they have $\delta^{44}Ca = -1$ to –2, it would indicate the existence of life. It has been recently proposed based on laboratory experiments that equilibrium inorganic precipitation of calcite causes –1.5‰ fractionation, which could negate this approach. However, calcite is notoriously hard to grow at equilibrium at low temperature so these results need verification. We present evidence from measurements in a natural system; 10- to 40-m.y. old deep sea carbonate ooze containing seawater pore fluid, that the equilibrium fractionation factor between calcite and dissolved Ca^{2+} is 0 ± 0.2‰. Results from further laboratory experiments, Martian meteorites, and models of early Martian weathering and oceans will also be presented.